

F16. I -Figur 10.

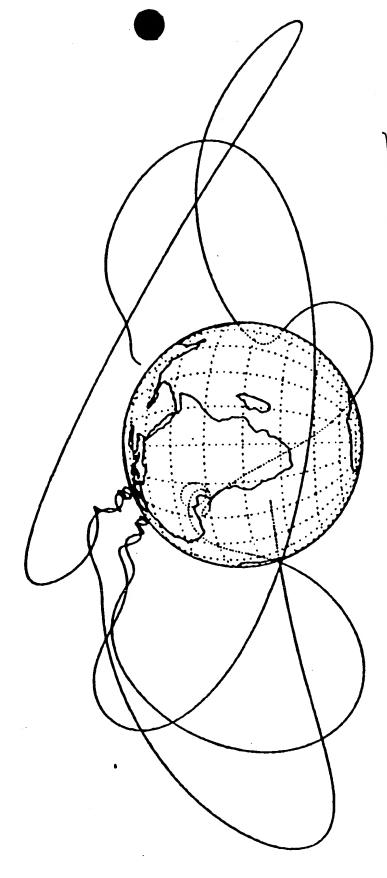


Fig. 5.1 - This figure shows the computed trajectory of a cosmic ray in the earth's magnetic field. Such complex trajectories are not unusual for cosmic rays in the penumbral shadow near the Stormer cutoff (Lund, 1980).

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Choose number of steps per each orbit (N_{spo}) of the Earth (e.g. $N_{spo} = 200$ steps), set orbit step counter N = 0 and number transmitted $N_{tr} = 0$, and specify required accuracy of numerical integration (typically 10^{-5}).

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Input orbital parameters: inclination, apogee, perigee, initial time (t₀), orbital duration (T), initial displacement of perigee from ascending mode, initial longitude of ascending node, and initial displacement from the ascending mode.

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Calculate orbital period (P) from input orbital parameters using standard orbit generation routines (e.g. Adams et al., 1986).
Calculate:

 $N_{max} = N_{spo} M_{adpos} T/P$ and $\delta t = P/N_{spo}$.

Find spacecraft's orbital location for time $t=t_0+N\delta t$ using numerical solution of standard equations for orbit generator, e.g. those given on pp. 43 - 48 of (Sterne, 1960), as implemented in the CREME orbit generator (Adams et al., 1986). Set particle trajectory time t'=t and time step $\delta t'=0$. Set M=0.

Differential equation for integrating is the Lorenz equation in magnetic field, using "backward" solution (Q replaced by -Q, t' replaced by -t') of:

$$F = m \gamma dv/dt' = Q v x B$$

$$\begin{split} B &= B_{IGRF}(r,t') + B_{Tsyg89}(Kp,r,t') \\ &+ \delta B_{\text{extended Tsyg89}}(Kp,Dst,r,t') \end{split}$$

NOTE: In the "backward" solution, the actual particle's final position is the initial position along the numerical integration of the "backward" particle trajectory, and the "backward" particle's initial velocity is in the opposite direction as the actual particle's final velocity.

See text for description of **B**-field calculations.

Set r = particle's final position and v = particle's final velocity vector. These are determined from the spacecraft's latitude, longitude, and altitude, combined with the particle's rigidity, final θ , and final φ .

Generate particle's final θ and φ for each orbital location, using random number techniques, i.e. x_1 and x_2 are two distinct outputs from a random number generator.

 $\cos \theta = \cos \theta_{\text{max}} + x_1 (\cos \theta_{\text{min}} - \cos \theta_{\text{max}})$

 $\varphi = \varphi_{\min} + x_2 (\varphi_{\max} - \varphi_{\min})$

M = M + 1

NOTE: many modern computers have built in random number generator functions. For computers which do not, one can use the subroutines for random number generation from (Press et al., 1992).

Evaluate B-field and d v/dt' at location r and time t' along the particle's trajectory, i.e. t' is the time along the particle's trajectory.

Specifically, perform Bulirsch-Stoer numerical integration, using formulae & algorithms as presented on pp. 718-725 of (Press et al., 1992). The outputs are the particle's radial position \mathbf{r} , velocity \mathbf{v} , and time $\mathbf{t}' = \mathbf{t} + \delta \mathbf{t}'$ after the numerical integration step; and an estimate of $\delta \mathbf{t}'$ for the next particle-trajectory integration time-step.

NOTE: $\delta t'$ is re-calculated within each execution of the adaptive Bulirsch-Stoer integration.

Evaluate if particle trajectory encountered solid Earth (forbidden), entered atmosphere (forbidden), crossed magnetospheric boundary (transmitted), or still within magnetosphere.

If transmitted, $N_{tr} = N_{tr} + 1$

If forbidden, $N_{fb} = N_{fb} + 1$

If within magnetosphere.

If transmitted or forbidden, N = N + 1

If $M < M_{adpos}$

If $N \leq N_{max}$

If $N > N_{max}$

Calculate Geomagnetic Transmission (GT) for this rigidity (R) and output the result:

 $GT(R) = N_{tr} / N_{max}$

NOTE: $N_{fb} = N_{max} - N_{tr}$

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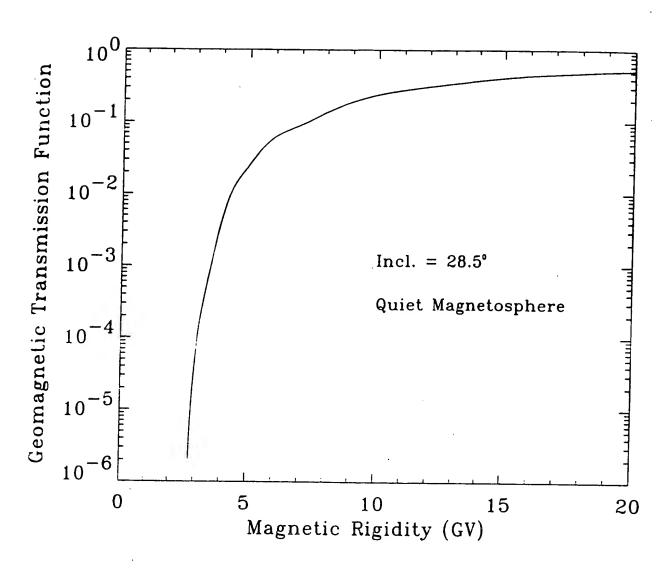
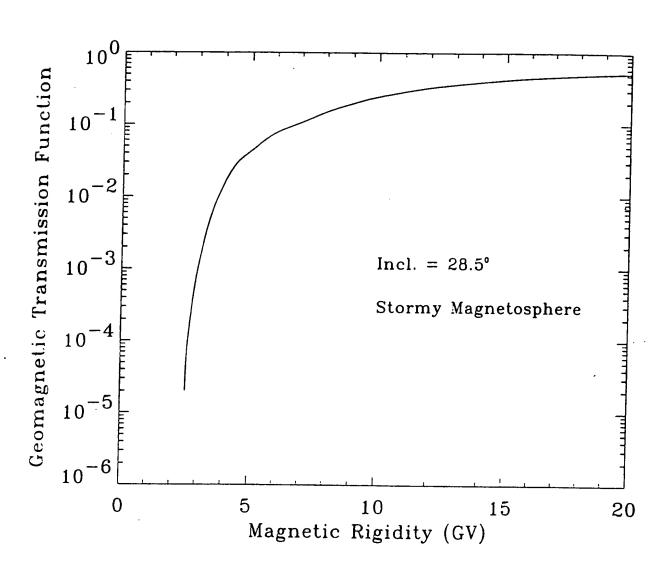
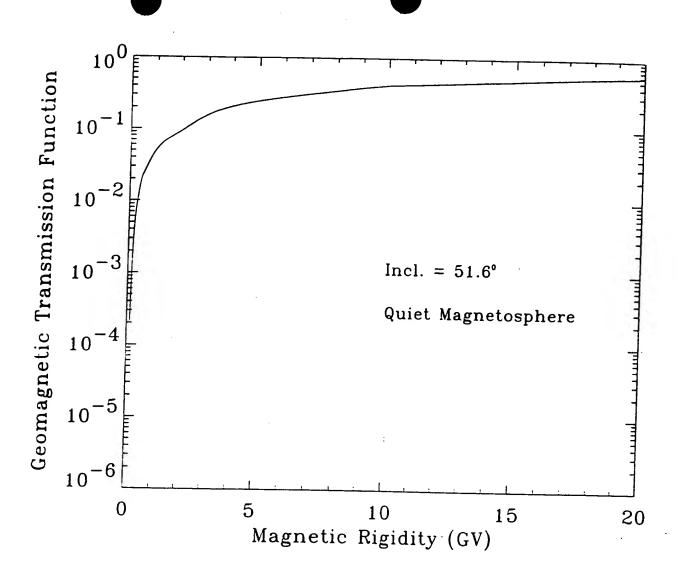


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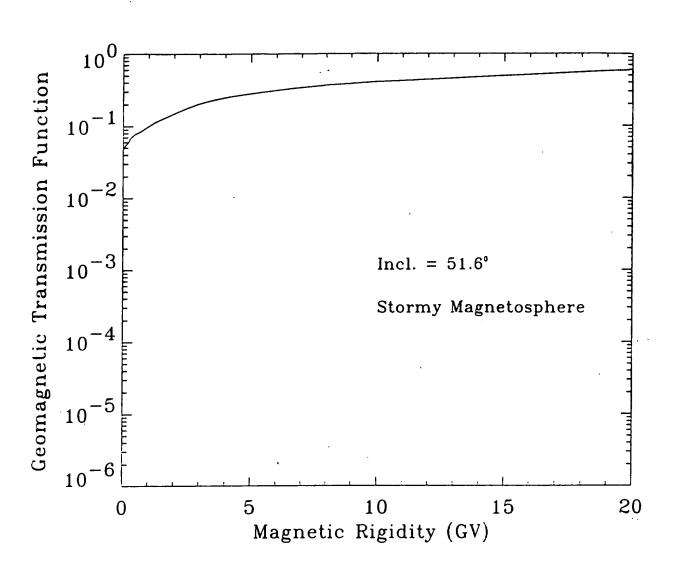
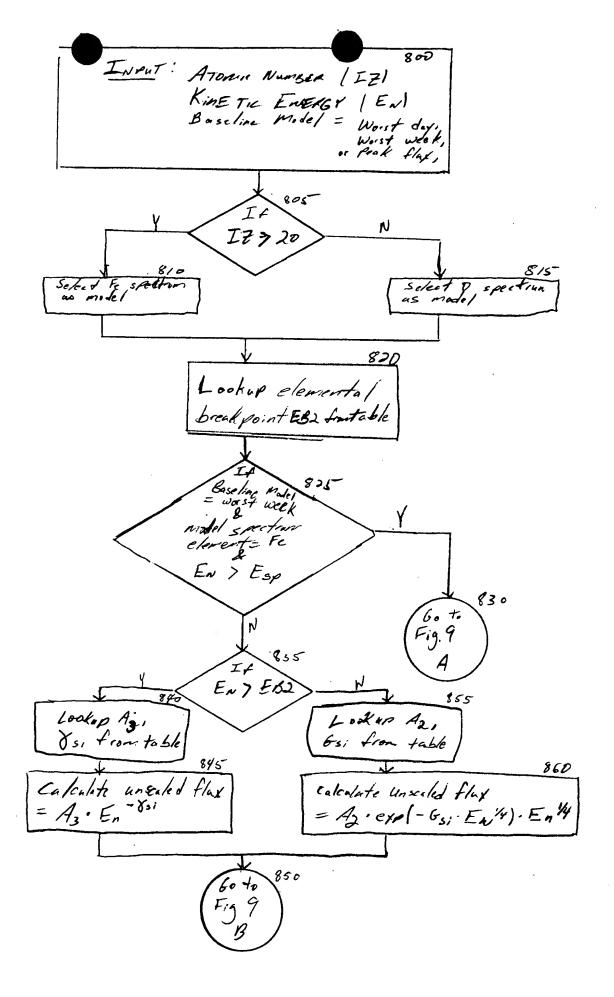
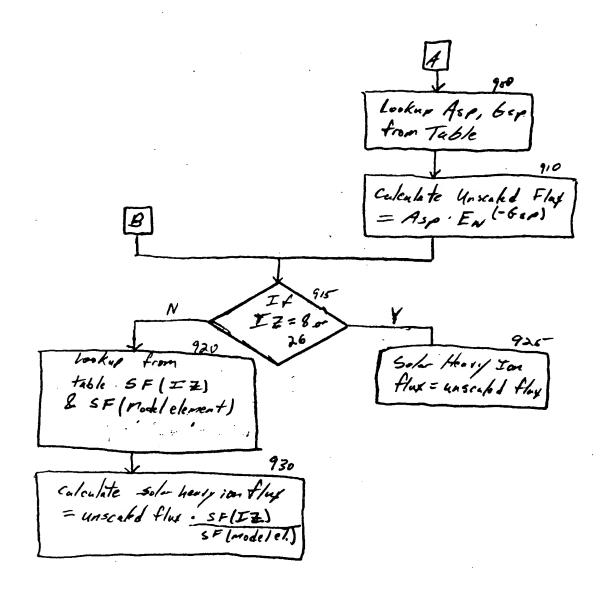


FIG. 7







CREME96 Main Men

See brief instructions at the bottom of this page. See How to Run CREME96 for more details.

GO	RESET FORM

Routine	User Request File list	Edit User Request File	Run Routine
TPS	▼.	0	
GTRN	V	. 0	
FLUX	V	0	
TRANS	V	0	
LETSPEC	F	0	
PUP	Ţ	0	
HUP	[7]	0	
UTILTIES (create plots, perform downloads, etc.)			П

1. To CREATE a User Request File:

- Click on the Edit button by the corresponding routine, leaving the User Request File blank. (If necessary, use the blank space in the pulldown menu to clear a name already typed there.)
- O Click on the "GO" bar.

2. To EDIT an existing User Request File:

- Click on the Edit button by the corresponding routine.
- Select a User Request File from the appropriate pull-down menu.
- Click on the "GO" bar.

3. To RUN one or more routines:

- o If an Edit button has been clicked "on", use the RESET bar to clear it.
- Select <u>User Request File(s)</u> from the appropriate pull-down menu(s).
- Click on the RUN button(s) in that line(s)
- o Click on the "GO" bar.

4. To access CREME96 Utilities:

- o Click on the RUN button on that line
- O Click on the "GO" bar.

Note: You can create or edit only one User Request File at a time. But you can submit several files for running (sequentially, in the order shown in the table) by shecking more than one "RUN" button and then clicking on the "GO" bar.

Questions? Comments? Send mail to tylka@crs2.nrl.navy.mil.

You may terminate your CREME96 session at any time.

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